RESEARCH HIGHLIGHTS

Technical Series 99-119

PRACTICAL GUIDELINES FOR DESIGNERS, CONTRACTORS, AND DEVELOPERS ON THE INSTALLATION OF AIR LEAKAGE CONTROL MEASURES IN NEW AND EXISTING HIGH-RISE COMMERCIAL BUILDINGS

Introduction

Inadequate air barrier systems allow leakage of air through holes, leaks, cracks, and gaps. Leaking air carries humidity as well as dust, dirt, and other contaminants. The worst areas of leakage are: mechanical penthouses; soffits; parapets; punched windows; overhang parapets; links connecting below-grade areas to other buildings; joints between one system and another; and doors. Faulty air barriers can lead to uncomfortable indoor environments, high heating and air conditioning costs, and accelerated decay of building materials.

The purpose of this document is to reduce the negative economic, environmental, and human impacts of inadequate, improperly designed, improperly installed, and improperly maintained air barrier systems. It also outlines practical techniques that can be used to virtually eliminate poor air barriers.

Choosing Air Barrier Systems:

According to the National Research Council of Canada, suggested maximum permeability for materials used in each class of barrier is as follows:

- Class 1 (relative humidity less than 27%): 0.15 L/s/m^2
- Class 2 (relative humidity 27-55%): 0.10 L/s/m^2
- Class 2 (relative humidity greater than 55%): 0.05 L/s/m^2

An air barrier system should be structurally supported so that it is durable, cannot shear, and is accessible for maintenance and repair. It can be located anywhere in the building envelope. Experts should be consulted at all times for advice on the location of the air barrier systems.

Research Program

Although there is little published information available to gauge the effect of air leakage through the building envelope in commercial buildings, there are some available statistics from a variety of studies:

- Data published in the ASHRAE Handbook indicates that air leakage in high-rise commercial buildings typically represents 15% to 30% of the building's thermal load (or roughly 4% to 8% of the total energy requirement).

- Other studies have reported theoretical savings in the 20% to 60% range based on detailed energy input/output audits. These same sources have observed air leakage control retrofit measures achieving a documented saving of close to 40% for one office building.

- A survey of four electrically heated high-rise residential buildings in Ontario shows that, during peak winter conditions, the air infiltration component contributed to the heating load by roughly 25% to 50% of peak heating demand.

- An Ontario Hydro field study in 1991/1992 evaluating the impact of air-sealing retrofit measures on energy and peak demand requirements of two high-rise residential buildings showed that:

- air sealing of leaks in the building envelope improved airtightness by 30 to 40%;
- air leakage control offered a reduction in peak space heating demand by 4 W/m^2 to 7 W/m^2 of floor space;
- indoor air quality tests showed no negative impact on comfort and air quality conditions; and
- simple payback period for air sealing retrofit was four to six years.

Tools that can used to assess the potential energy and cost benefits of air leakage control include the air leakage control assessment procedure (ALCAP) developed by Ontario Hydro.

The High Cost of Air Leakage:

Wind pressure and stack effect on buildings with faulty air barriers can create pressure imbalances and lead to airborne humidity, corrosives, and contaminants that can do untold damage to insulation, brickwork, cladding, and decorative facings.

Decaying building materials reduce the life of the building, increase operating and maintenance costs, lead to increased tenant complaints, and endanger the safety of passersby.

Uncontrolled air leakage also causes problems for people in the building, in the way of reduced comfort, poor morale, health problems, and absenteeism from work.

From an aesthetic standpoint, air barrier problems can also lead to efflorescence, water staining, flaking bricks, rust streaks, large holes in masonry, and cracked and peeling finishes.

Recommendations:

Many materials have the characteristics required for air barriers. Unsupported polyethylene film cannot be recommended as an air barrier material for high-rise buildings because of its susceptibility to damage.

Recommended **jointing materials** for air barrier systems include:

1. Sealants: caulking materials, mastics, coatings, etc.
2. Weatherstripping: gaskets, packing, etc.
3. Foams: single- and two-component polyurethane
4. Membranes: sheet and liquid applied

Primary air barriers (rigid) have sufficient strength and stiffness to be fastened to an intermediate support or directly to the primary structure of the building. Materials include:

1. Cast-in-place concrete
2. Precast concrete
3. Gypsum board products (accessible drywall and non-accessible drywall approaches)
4. Plywood and particle boards
5. Sheet steel
6. Glass

There are also **prefabricated assemblies** that consist of multiple cast or assembled components that may be face-sealed or contain a non-accessible plane or airtightness within assembly. Options are:

1. Precast concrete cladding and sandwich panels
2. Curtain wall systems
3. Exterior insulation finish systems (EIFS)
4. Windows and doors

Locations of Weaknesses:

There are a number of locations where weaknesses in the air barrier system are commonly found or inadequately detailed, ranging from below-grade areas and basement and ground-floor junctions to building core walls and floor slab/wall joints, roof/wall joints to mechanical/electrical rooms, and laundry and garbage rooms. Other areas include corridors, vestibules and elevator lobbies, pipe duct and conduit penetrations, service and inspection hatches, and loading bays.

Exterior walls and roofs of buildings above grade are commonly understood to incorporate the primary air barrier system of the building. Though these assemblies are generally known, junctions of dissimilar materials in new construction and restoring or providing air barrier systems in older buildings remains a problem.

There are seven common junction locations in the building envelope:

- Roof to wall
- Floor to wall
- Wall to window
- Wall to soffit
- Wall to foundation
- Junctions of dissimilar materials
- Compartmentalization of cavities

Air barriers designed into the junction must offer impermeability to air, continuity, structural strength and durability, as well as continuous support against wind loads. Care must be taken to ensure that the air barrier is flexible at the joints.

Design and Contracting Procedures:

Design and contracting procedures can vary for designers and contractors for both existing and new buildings. It is important that each group follows the recommended procedures to ensure optimum results.

There is also a wide selection of literature available on industry guidelines and requirements for selecting and installing air barrier systems.

TABLE 1:
RELATIVE AIR PERMEABILITY OF VARIOUS MATERIALS
Measured leakage at 75 Pa.

Test Material	Thickness in mm	Liters/ sec/m^2
Various bitumen based membranes	2 to 3	None
Plywood sheathing	9.5	None
Extruded polystyrene insulation	38	None
Foil backed urethane insulation	25	None
Phenolic insulation	24	None
Cement board	12	None
Foil backed gypsum board	12	None
Sprayed-in-place polyurethane foam	53	None to .00024
Flake board	16	.0069
Rainscreen exterior insulated finish system (EIFS)	-	.007
Gypsum board (moisture resistant)	12	.0091
Flake board	11	.0108
Particle board	12	.0155
Reinforced perforated polyolefin	-	.0195
Gypsum board	12	.0196
Particle board	16	.0260
Tempered hardboard	3	.0274
Expanded polystyrene Type 2	-	.1187
Roofing felt # 3	-	.1873
Non-perforated asphalt felt # 15	-	.2706
Perforated asphalt felt # 15	-	.3962
Glass fiber rigid insulation board with spun-bonded olefin film one face	-	.4880
Plain fibre board	11	.8223
Asphalt impregnated fiber board	11	.8285
Spun bonded olefin film	-	.9593
Perforated polyethylene # 2	-	3.231
Perforated polyethylene # 1	-	4.032
Glass fiber insulation	-	36.73
Vermiculite insulation	-	70.49
Cellulose insulation (spray)	-	86.96

According to NRCC, suggested maximum permeability for three different classes of air barrier is as follows:

Class 1	*RH less than 27%*	*0.15 l/s/square meter*
Class 2	*RH 27 to 55%*	*0.10 l/s/square meter*
Class 3	*RH greater than 55%*	*0.05 l/s/square meter*

Project Manager: Al Wiseman

Research Report: Practical Guidelines for Designers, Contractors, and Developers on the Installation of Air Leakage Control Measures in New and Existing High-Rise Commercial Buildings

Research Consultant: Canam Building Envelope Specialists Inc., with assistance from Carson Woods Architects Limited and EMS Marketing Communications Inc.

Prepared for: Public Works and Government Services Canada.

A full copy of the report is available from the Public Works Documentation Centre. Document ST-152

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Housing Research at CMHC

Under Part IX of the National Housing Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research report.

Building Research at PWGSC

As custodian of many Federal Government assets, PWGSC provides funds to the Technology Development and Transfer program to investigate, and promote the use of new and innovative technologies that will achieve both short term and long term savings and improve the durability of our buildings.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's and PWGSC's research, and highlights a technical report prepared for PWGSC.

The Research and Development Highlights fact sheet is one of a wide variety of housing related publications produced by CMHC.

For a complete list of Research and Development Highlights, or for more informaiton on CMHC housing research and informaiton, please contact:

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